Smith (J. Law.)

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ON SOME OF THE

THERMAL WATERS

OF ASIA MINOR.

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Part I.—*The Thermal Waters of Broosa.*

THERE are few countries where Thermal Waters are so numerous, and cover so extensive a surface as in Western Asia Minor; many of them still bear marks of the estimation in which they were held by the ancient Romans and Greeks for the purpose of supplying their baths.

Owing to the difficulty of obtaining proper vessels or corks at or near the springs, coupled with the risk of breakage by the necessary transportation on the backs of horses over rough and mountainous roads, travellers have been deterred from collecting these waters for the purpose of analysis. In my travels through certain parts of this country, I took along with me bottles and corks, and collected between twenty and thirty specimens of different localities, some of them in considerable quantity; and of that number fifteen or sixteen have arrived safely to my laboratory, where most of them have been already examined.

In my remarks upon them I will first allude to the thermal waters of Broosa or Prusia, which are the most important at the present day, and the most accessible from Constantinople. The spot itself is hallowed by many interesting historical associations. The city was founded by Hannibal during a friendly visit which this great Carthagenian general made to Prusias, the king of Bythinia, whose name was given to it. Like all other cities of so ancient date, it has gone through many changes, passing successively into the hands of the Greeks, Romans, and Turks. Since 1326 the Turks have continued masters of this part of Asia Minor, it having been conquered by Osman just prior to his death, for many years after which event it remained the capital of the Ottoman empire.

Broosa is readily reached from Constantinople by a steamer that goes from this latter place to Modania, on the gulf of the same name, about seventy miles from Constantinople. From Modania a ride of about twenty miles on horseback brings you to Broosa, at the foot of the Bythinian Olympus. The warm baths of this place have been celebrated from the earliest epochs, and the visit of Constantine with his wife in 797, is recorded in history as having resulted favorably in restoring the latter to health. And at a still later period Sultan Soleman the Great visited these baths on account of an attack of gout, and to commemorate his cure he had a large dome constructed over the source to which he attributed the beneficial effects derived by him; the dome still stands.

As it is not my object to enter here into the details of baths well known to all travellers in this part of Asia Minor, I shall at once proceed to the description of the sources. The sources of thermal waters near Broosa are seven in number, all situated in a little valley which separates *Mount Olympus* from *Mount Katairli*, and they are comprised within the distance of a mile and a half. In the immediate neighborhood of some of these sources, and sometimes in direct proximity, are sources of cool and delightful water that serve to regulate the temperature of the water used in the baths, of which there are as many as twenty private and public. These sources furnish waters of two description, the sulphurous and the non-sulphurous, and I shall commence with a description of the former.

THERMAL SULPHUR WATERS.

There are two sources of this class of water near Broosa, or rather two places near to each other where it flows out of the mountain, for my examination goes to prove that they are the same water. Their names are *Kukurtlu* and *Bademli-Baghtsche.*

Kukurtlu Source.

The name of the source signifies sulphur. It flows rapidly from the side of the mountain near to its base, through a bed of calcareous tufa, furnishing upwards of twenty gallons a minute, which, along with the water from a cold spring near by, is made to flow through the baths. There is a very sensible odor of sulphuretted hydrogen proceeding from the water of this source, more especially as it issues forth from the mountain, for there is a large amount of gas bubbling through the small reservoir into which the water rises, accompanied with a larger amount of vapor. As the water flows it leaves an incrustation of carbonate of lime, more or less colored with some organic matter. This source is held in particular veneration by the Greeks of the country, who usually assemble here twice a year to commemorate the martyrdom of St. Patrice, which was ordered by the Pro-consul of Broosa, and executed by his being thrown into this almost boiling spring.

The country is *geologically* made up of the older rocks, as granite, gneiss, limestone, &c., a silicious variety of the latter overlying the other two; in some parts, however, the limestone is remarkably pure, and has doubtless furnished to these waters that carbonate of lime so extensively deposited at the base of this part of the mountain in the form of tufa, which, for a mile or two of extent, rises several hundred feet above the plain at the foot of the mountain.

Physical Properties.—The water as taken from the source is perfectly clear and transparent, and remains so when kept in well corked bottles, but otherwise a yellow deposit is soon formed which

is probably crenate of lime. A slight odor of sulphuretted hydrogen, not perceptible when the water is cold. The taste of the water when cold is in no way peculiar, and it is very pleasant to drink. Specific gravity 1·00118. Temperature, (atmosphere at 66° Fah.,) 182° Fah., which varies but a few degrees with the seasons.

Chemical Composition.—The *gas* which escapes from the source was collected in inverted bottles, well corked and sealed, and in one thousand parts was found to contain—

Carbonic acid,	886
Nitrogen,	99
Oxygen	11
Sulphuretted hydrogen,	4

Solid contents in one litre of the water, 970 grammes. The water is alkaline, and, when concentrated to one third its bulk, gives a very sensible alkaline reaction with reddened litmus paper. It is found to contain the following ingredients in one litre:

	Grammes.		Grammes.
Carbonic acid, free,*	·3420	Lime,	·1415
Carbonic acid, fixed,	·1820	Magnesia,	·0142
Hydro-sulphuric acid,	·0012	Alumina,	·0012
Sulphuric acid,	·2140	Silica,	·1100
Chlorine,	.0103	Iron,	trace
Soda,	·2600	Organic matter (crenic acid),	·0350
Potash,	·0110		

These acids and bases may be represented as combining in the following manner:

Bi-carbonate of soda,	.4100	Sulphate of alumina,	·0043
Bi-carbonate of lime,	·1830	Chlorid of sodium,	·0170
Bi-carbonate of magnesia,	·0460	Hydro-sulphate of soda,	·0033
Sulphate of soda,	·1950	Carbonate of iron,	trace
Sulphate of potash,	·0202	Silica,	·1100
Sulphate of lime,	·1710	Organic matter,	·0342

The incrustation from this spring was next examined. One gramme of a beautiful crystalline portion was analyzed and found to contain—

Carbonate of lime,	·970	Silica,	003
Carbonate of magnesia,	·016	Organic matter,	trace
Sulphate of lime,	·008	Fluorid of calcium,	trace
Peroxyd of iron,	·011		

There are some portions of the incrustation richer in organic matter than this, but then the mixture is sensible to the eye, and does not represent the pure crystalline deposit of the spring.

* What is here meant, is, such of the carbonic acid as can be expelled in boiling the water.

The *Kukurtlu* source supplies two baths with water, one called the *Buyuk Kukurtlu* and the other the *Kutschuk Kukurtlu.*

The other source of sulphur thermal water is called—

Bademli Baghtsche.

This source is about three hundred feet from the latter, and flows from three or four openings in the tufa. On my visit to it the entrance to the sources was closed up with masonry, and the door could not be opened by the Turks from some superstitious motive. I was, however, enabled to procure the water a few feet from the source as it flowed through an open gutter; gas is said to escape abundantly from the source, just as in the Kukurtlu source.

Physical Properties.—It is clear and transparent, remaining so in well corked bottles; exposed to the air it gradually becomes cloudy, and deposits a yellowish sediment. Has a slight odor of sulphuretted hydrogen when warm. Specific gravity 1·00116. Temperature, (atmosphere at 67°,) 184° Fah.

Chemical Composition.—Solid contents, ·978 grammes in one litre. The water when concentrated reacts strongly alkaline. In one litre there are the following ingredients in grammes:

Carbonic acid, free, .	·2920	Lime, . . .	·1378
Carbonic acid, fixed, .	·1875	Magnesia, . . .	·0160
Hydro-sulphuric acid, .	·0010	Alumina, . . .	·0005
Sulphuric acid, . .	·2160	Silica, . . .	·1100
Chlorine, . . .	·0112	Iron, ...	trace
Soda, ...	·2650	Organic matter (crenic acid?), . .	·0402
Potash, . . .	·0130		

The combination of the acids and bases may be represented in the following manner:

Bi-carbonate of soda, .	·4070	Sulphate of alumina, .	·0020
Bi-carbonate of lime, .	·1790	Chlorid of sodium, .	·0192
Bi-carbonate of magnesia,	·0520	Hydro-sulphate of soda,	·0019
Sulphate of soda, .	·2000	Carbonate of iron, .	trace
Sulphate of potash, .	·0225	Silica, . . .	·1100
Sulphate of lime, .	·1660	Organic matter, . .	·0402

Two baths are also supplied from this source, the one called *Yeni-Kaplidja* and the other *Kainardja.*

It will be seen that in physical properties and chemical composition, the water of this source is identical with that of Kukurtlu; at which fact I was at first somewhat surprised, as an approximate analysis made some years ago by Dr. Bernard led me to look for a difference in the composition of these waters; and it was not until my analysis was completed that I became convinced that the waters of the Kukurtlu and Bademli-Baghtsche sources were the same, making its way through different openings in the tufa. I would merely remark here, that the an-

alysis made by Dr. Bernard must have been quite crude, as among other things he gives to a litre of the Kukurtlu water ·332 grammes of sulphuretted hydrogen, water which, when cold, has no hepatic odor, and has hardly a sensible effect on lead water.

None of the other sources near Broosa evolve a trace of sulphuretted hydrogen, and contain less solid matter; they are all alkaline, and give an alkaline reaction when concentrated.

THERMAL ALKALINE WATERS.

Of the alkaline waters, I have examined three sources situated at some distance from each other.

The *Kara Mustapha* source is about two hundred yards from the *Kukurtlu*, and almost on the border of the plain of Broosa; it supplies a bath bearing the same name.

Physical Properties.—Clear when taken from the source and kept in well stopped bottles. As the opening in the mountain from which it escapes is bricked over, it was impossible for me to ascertain if there were an abundant escape of gas. Temperature, 127° Fah. Specific gravity 1·00094.

Chemical Composition.—Solid contents in one litre ·541 grammes, and the same quantity of the water contains—

Carbonic acid, free,	·104	Lime,	·115
Carbonic acid, fixed,	·150	Magnesia,	trace
Sulphuric acid,	·068	Iron,	trace
Chlorine,	·005	Silica,	·066
Soda,	·132	Organic matter,	not estimated.

The combinations of the acids and bases may be represented as follows, in grammes:

Bi-carbonate of soda,	·2600	Chlorid of sodium,	·0084
Bi-carbonate of lime,	·2380	Carbonate of iron,	trace
Sulphate of soda,	·0452	Silica,	·0660
Sulphate of lime,	·0670	Organic matter,	not estimated.
Carbonate of magnesia,	trace		

Incrustations of carbonate of lime are deposited from this source, but not so abundantly as from the two first mentioned.

Tschekirghe Source.

The Tschekirghe source is about a mile and a half from Broosa, and supplies four baths, those of *Boigusel*, *Vani*, *Tschekirghe*, and *Yeni-Han*.

Physical Properties.—Clear, and does not readily deposit a sediment; the incrustation much less than at the other sources. No gas escapes from it as it flows from its source. Temperature, (air at 72° Fah.,) 113° Fah. Specific gravity 1·00068.

Chemical Composition.—Solid contents in one litre ·550 grammes; the same amount of the water contains—

Carbonic acid, free,	·040	Lime,	·168
Carbonic acid, fixed,	·094	Magnesia,	trace
Sulphuric acid,	·152	Iron,	trace
Chlorine,	trace	Silica,	·040
Soda,	·039	Organic matter, not estimated.	

Combined as—

Bi-carbonate of lime,	·2336	Sulphate of lime,	·2190
Carbonate of soda,	·0480	Chlorid of sodium,	trace
Carbonate of magnesia, Carbonate of iron,	traces	Silica,	·040
Sulphate of soda,	·0250	Organic matter, not estimated.	

The last source that I shall allude to is a very small one near to the *Kukurtlu*, and not connected with any bath, it is, however, used by the natives for the treatment of diseased eyes.

Gueuzayasma Source.

The Gueuzayasma source rises slowly in an excavation in the side of a rock, no gas whatsoever escaping from its surface; an incrustation is formed from it, that is in some places covered with a thin green coat resembling some of the salt of nickel or copper, it is, however, entirely of a vegetable character, and exhibits under the microscope a beautiful lace structure.

Physical Properties.—Clear and transparent; Temperature, 113° Fah. Specific gravity, 1·00122.

Chemical Composition.—Solid contents in one litre, ·901 grammes. One litre of the water contains—

Carbonic acid, free,	·220	Lime,	·175
Carbonic acid, fixed,	·150	Magnesia,	trace
Sulphuric acid,	·215	Iron and alumina,	trace
Soda,	·151	Silica,	·114
Potash,	·006	Organic matter, not estimated.	

Combined as follows:

Bi-carbonate of soda,	·2405	Sulphate of lime,	.2370
Bi-carbonate of lime,	·2249	Sulphate of alumina,	trace
Bi-carbonate of magnesia,	strong trace	Carbonate of iron,	trace
		Silica,	·1140
Sulphate of soda,	·1160	Organic matter, not estimated.	
Sulphate of potash,	·0110		

The incrustation of the spring contains 97 per cent. of carbonate of lime, the remainder is composed of carbonates of iron and magnesia and the sulphate of lime without a trace of fluorine.

These various springs it will be seen supply nine public baths, which vary in their size and magnificence, that of *Yeni-Kaplidja* being the largest and most beautiful; they are constructed on the usual plan of the Eastern baths, and consist of three parts:

First, a large hall, with an elevated platform all around two feet high, and sometimes galleries attached. It is on the platform that one disrobes himself prior to entering the bath, and it is also here that the bather reposes on a couch in retiring from the bath. This apartment is frequently ornamented with considerable luxury; it is well lighted, and there is sometimes in the middle a fountain, the falling of whose waters in the basin produces a freshness, and at the same time invites to slumber. This apartment is called by the Turks *Djamekian* (Vestiarium).

The next division in the bath is the *Soouklouk*, where one begins to experience the temperature of the inner bath, and where he reclines on a marble slab, and is either shampooed or places himself in the hands of the barber to be shaved, cupped or bled.

The third division is the *Hammam*, or bath properly speaking, where there is an atmosphere of 105° to 110° Fah., filled with the vapor of water arising from the heated marble floor. Here there are various recesses with small marble basins in which streams of hot and cold waters are allowed to flow; and once seated by one of them, an attendant of the bath takes possession of you, and puts you through a series of operations that can be better felt than described. The baths at Broosa have usually in the *Hammam* a large basin of hot water, into which the bathers can plunge, the one in the *Yeni-Kaplidja* is about five feet deep by thirty in diameter.

There is in some of these baths a small room called the *Boghoulouk* (Sudatorium), where the temperature is from 120° to 130° Fah. Once through the various operations of the bath one returns to the first room, reclines on a bed and indulges for a half hour or more in the Eastern luxuries of smoking and drinking coffee or sherbet.

This is a hasty sketch of the operations that the bather usually undergoes at these baths; but as numbers of invalids visit them, arrangements are made by which they can bathe in whatsoever way they may think best or the physician prescribe, for there are private apartments attached.

These thermal waters are in great repute in Turkey, and their effects are said to be most marked on chronic irritation of the abdominal organs; chronic rheumatism; gouts; chronic irritation of the mucus membrane of the intestines; diseases of the bladder, of the skin, and of the eyes, &c. These waters are also recommended to be taken internally when cold.

In the calcareous incrustation of three of these springs that were examined, I found the remains of two or three varieties of silicious infusoria after the lime had been dissolved out by an acid.

Some few remarks that I have to make with reference to the chemical analysis of these waters will be deferred until the publication of the second part of this paper.

New Orleans, March 14th, 1851.

Part II.—*Waters of Yalova, Hierapolis, Eski-shehr, Troy, Mitylene and Tiberias.*

*Thermal Waters of Yalova.**

The shortest way of reaching the springs of Yalova is by landing on the south side of the Gulf of Nicomedia, near to *Angori*, (three hours distant from Constantinople by steamer,) and proceeding along a beautiful plain, that gradually narrows until terminating in a valley closely shut in by hills. The springs in question are situated in this valley, about six miles from the sea; they are at the foot of a hill, which on the southwest closes in the valley of Yalova and are known in the country by various names, as *Couri-Hamam, Dagh-Hamam*, &c.

On the road that approaches the springs, there are extensive remains of the foundations of old Roman and Grecian buildings, and still nearer, the remains are more perfect, in the form of arches,

* The locality of these waters is described very fully as it is but little known, being seldom visited by travellers.

aqueducts, baths, &c. Their extent gives evidence of the celebrity they enjoyed in former times. The styles of their architecture belong to different periods. The remains of the brick edifices are evidently of the period of the Lower Empire, for on many of the bricks are to be found an impress of the cross, and Latin words written in Greek letters. To judge from the form of these letters, particularly the epsilons, sigmas and omegas, one is led to believe that they date from the Justinian age. The massive stone arches, which support the vault under which the waters rise, seem to have been constructed by the Romans. Their structure presents nothing which opposes the idea received by the inhabitants of the surrounding villages, namely, that they were constructed during the reign of Constantine the Great. And what seems to sustain this hypothesis, is, the popular legend that the mother of Constantine was indebted to these waters at one period of her life, for her restoration to health; and from this fact (according to the authority of the celebrated archæologist, the Patriarch of Constantius) Yalova was formerly called Helenapolis.

In want of more exact data we may cite as sustaining this supposition, the custom of the Greek villagers of the neighborhood, kept up for many centuries, of assembling at these baths on the anniversary of the *fêtes* of St. Constantine and St. Helena, to celebrate the virtue of these waters. Von Hammer in his history of the Turkish Empire, alludes to this place in the following words: "Some leagues from *Cara-Mursal* on the south side of the Gulf of Nicomedia, there exist the baths of Yalova (ancient Sergla or Trepanon). This place was adorned with a great number of palaces and hospitals by the Empress Helen, whose father had kept an inn there. This place was afterwards raised to the rank of a city by Constantine, the founder of the Byzantine empire, and called Helenapolis in honor of his mother. It was to this place that the first army of the crusaders, conducted by Peter the hermit and Gautier *sans-avoir*, took refuge after being routed near Nice. It was here also that the Saracens constructed pyramids and towers with human bones. Helenapolis has been at all times celebrated for its thermal waters. Near their source is to be seen the tomb of an *Abdal*, that is, an enthusiastic dervish, who armed with a wooden sword undertook at the head of a body of Mussulmans to conquer this city."

There are several ancient authors who allude to these springs, among whom are Ammianus, Marcellinus, Mela, and Anna Commenus.

Yalova, which is now but a small village, was formerly the place of debarkation for the inhabitants of the celebrated cities of Nicomedia, of Nicea, and of the numerous cities of Bithynia, who visited these springs. The port of Couri, whose antiquity is

indicated by several Greek inscriptions, was probably, as now, frequented by those coming from Constantinople and other cities of the Propontide.

After the fall of the Roman empire, these baths went to ruin, and were almost forgotten; nevertheless the reservoirs and aqueducts remain as in the time of the Lower Empire. It is only a few years since an Armenian banker purchased the place and constructed houses for the reception of the sick.

These waters have at least *nine* sources. They flow from the sides and bottom of a hill, rising through a sandy bottom accompanied with bubbles of gas, and differ but little in their temperature and composition. The character of the surrounding rocks is not easily made out; I am inclined to refer them, from my observations higher up the gulf, to the older tertiary. The waters in their course leave not the slightest deposit, so that the ancient aqueducts have never become obstructed.

According to the accepted classification, the mineral waters of Yalova belong to the *hot sulphurous waters*. They have at their source a very slight odor of sulphuretted hydrogen, but the quantity is so small, either in the water or the gas, that it could not be estimated. The temperature of the waters is from 151° to 156° Fah., and varies but little with the changes of the atmospheric temperature. The water is limpid and transparent, and has the specific gravity 1·00115.

The gas which escapes at the source gave on analysis,

Nitrogen, - - -	97 per ct.
Oxygen, - - -	3

One litre of the water gave 1·461 grammes of solid matter. —The same quantity of water contains in grammes,

Sulphuric acid, . .	·690	Magnesia, . . .	·002
Chlorine, . . .	·086	Alumina, . . .	*trace*
Soda, ...	·393	Silica, ...	·035
Lime, ...	·208		

Combined in the following manner:—

Sulphate of soda, . .	·807	Sulphate of magnesia, .	·005
Sulphate of lime, . .	·414	Sulphate of alumina, .	*trace*
Chlorid of sodium, .	·072	Silica, ...	·035
Chlorid of calcium, .	·068		

The composition of these waters resembles that of the Bath waters of England, the latter however not being of so high a temperature. They act powerfully on the nervous system and on the secretions and excretions, particularly those of the skin; which renders them so efficient in rheumatism, gout, &c.

Thermal Waters of Hierapolis.

The ruins of the ancient city of Hierapolis are among the most interesting in the southwestern part of Asia Minor. The place is situated about six miles from Laodicea (one of the seven churches) and about one hundred and ten miles from Smyrna. The site is seen for many miles before it is reached, as it rises abruptly from the north side of an extensive plain, and the sides of the hill are covered with an incrustation of dazzling whiteness for upwards of a mile in length, and from this it has received its present name, Pambuk-kelesey, (cotton castle.)

This place was much admired in former times, if we are to judge from the inscriptions still to be seen on different parts of the ruins, to the following effect. "Hail, golden city, Hierapolis; the spot to be preferred before any in wide Asia; revered for the rill of the nymphs, adorned with splendor;" the people, in some of these inscriptions, are styled, "the most splendid," and the senate, "the most powerful."

It is a place well known to travellers in this part of the world, and therefore I shall confine myself strictly to what concerns its thermal waters, which have ever been its principal object of note, as evinced by the extensive ruins of baths. In fact the very hill upon which the city stands owes its formation to the deposition of carbonate of lime from these waters, and it now rises upwards of a hundred feet above the plain with a width of about six hundred feet. Immediately behind the city, rises another set of hills of calcareous rock, from which flow the waters in question; they first enter a large pool in front of the theatre, and from this the water flows in numerous little streams that course in channels made by incrustations from the water. The amount of water is very great, and it is so highly charged with carbonate of lime, as to incrust all bodies that it comes in contact with, and it takes place so rapidly that the concretion does not possess great solidity, and frequently has a granular form resembling driven snow.

It is this incrustation, as I before said, which gives to the immediate site of the city its remarkable character. In some places as the waters flow over the steeply inclined sides of the hill, it forms a succession of terraces at regular distances, that require but little effort of the imagination to liken to an amphitheatre with its marble seats. At other places, it flows over the precipitous sides sixty or seventy feet high, and one or two hundred feet wide, incrusting the precipice with a snow-white sheet which might be likened to a consolidated cataract, and what adds to the delusion, at the base the incrustations have accumulated an irregular mass not unlike foam. This petrified stream extends several hundred feet into the plain. It has formed walls and

dikes, and incrusts the grass and vegetation that it flows over, and many of the tufts of grass, in perfect verdure, are thickly incrusted near the roots with this white carbonate of lime.

The channels that conduct the water through the city are made by deposits from these waters; many of them are very deep and almost arched over. The incrustations in and about the city have elevated the level of it some fifteen or twenty feet, since its destruction. Strabo tells us, that in his day the people of this city conducted these waters into their gardens or other places where they desired to form a wall, and in a short time they obtained fences of a single stone, so rapid was the deposition. The road which leads from the plain to the city is a causeway which is formed entirely from the water.

Physical Properties.—The water is of remarkable transparency, and remains so after being kept for any length of time. Having lost my thermometer the day before arriving at this source, I was unable to ascertain its exact temperature. I judged it to be about 130° Fah. Specific gravity, 1·00143.

Chemical Properties.—Solid contents in one litre, 1·934 grammes. One litre contains in grammes:

Carbonic acid, free,	·352	Potash,	*trace*
Carbonic acid, fixed,	·462	Lime,	·589
Sulphuric acid,	·541	Magnesia,	·164
Chlorine,	·012	Silica,	·008
Soda,	·182	Phosphoric acid,	·005

The combination of acids and bases may be represented in the following manner.

Bi-carbonate of soda,	·078	Sulphate of lime,	·119
Bi-carbonate of lime,	1·368	Sulphate of magnesia,	·431
Bi-carbonate of magnesia,	·041	Phosphate of lime,	·012
Chlorid of calcium,	·020	Silica,	·008
Sulphate of soda,	·341		

The *incrustation* of the spring was analyzed; it is remarkably white, and almost pure carbonate of lime. The composition is as follows.

Carbonate of lime,	98·2
Silica,	00·6
Magnesia, Phosphate of lime, Fluorid of calcium,	1·2 = 100·0

At the present day these waters are not used, and the neighboring country is quite deserted, with the exception of a miserable village of some half dozen huts. In former times, however, beside the use of this water for the baths, it was greatly in repute

among the dyers in a purple color made from a kind of root, and owing to the remarkable adaptation of this water for that purpose, the tint obtained is said to have rivalled the more costly purple, and to have constituted the principal source of riches to the city. The company of dyers is alluded to in the inscription on a square building among the sepulchres. These waters also seem to have possessed medical virtues, if we are to judge from some of their medals, on which you find Apollo (the tutelar deity of Hierapolis) with Æsculapius and Hygeia.

Strabo alludes to a circumstance connected with these waters that I inquired into while there, but without success. It is the existence of what that author calls a *Plutonium*, described as an opening about the size of a man in the side of the hill, with a kind of enclosure of half an acre in front of it; from the opening there issued constantly a dark vapor, that filled the enclosure in front of it. He states that all animals entering this enclosure became suffocated, but that the sacred eunuchs who attended in the temples could enter with impunity.

I sought to discover this *plutonium* but without success, it was doubtless an opening in the rock, from which issued a mixture of carbonic acid and vapor of water, that has subsequently become obstructed.

Thermal Waters of Eski-Shehr.

Eski Shehr is the ancient Dorylæum, the plains of which are very extensive. It is mentioned by the Byzantine writers as the field of the first battles between the soldiers of the Eastern empire and the Turks. It is situated on the river Pursceck or Thymbius, which empties into the Sangarius, that flows into the Black Sea, and is equidistant from that sea and the sea of Marmora, being a little over one hundred miles from each.

Eski-Shehr is a city of some importance to the Turks, and it is from here that Europe derives the greater portion of that mineral called Meerschaum, used in making pipes.

In a certain quarter of this city, by excavating to the depth of a few feet, hot water is obtained, which is a matter of great annoyance to the inhabitants, as they can have no wells of drinking water. It is in this quarter that are situated the celebrated hot baths, doubtless used for more than two thousand years, with such change in structure as time and the habits of the people required. There is here a large excavation sixty or eighty feet square, closed in with stone and roofed over; its depth I did not measure, but am told that it is twelve or fifteen feet. The water arrives from many sources at the bottom of this reservoir.

The reservoir was made by the Greeks and repaired some years ago by the Turks. The amount of water furnished is

very great, and forms half the water used in turning a mill in the neighborhood.

The water is allowed to flow from the great reservoir into a large Turkish bath, as well as from different hydrants for the purpose of washing dyed stuffs, &c.

Physical Properties.—This water is clear and transparent, and when cold it is very agreeable to the taste; no gas escapes from it, nor is there any deposit, even after very long repose. Temperature 119° Fah. Specific gravity 1·00017.

Chemical Composition.—The solid contents in one litre ·260 grammes. One litre of the water contains in grammes—

Carbonic acid, free,	·118	Soda with a little potash,	·119
Carbonic acid, fixed,	·195	Lime,	·040
Sulphuric acid,	·030	Silica,	·008
Chlorine,	*trace*		

Combined as follows:—

Bi-carbonate of soda,	·219	Sulphate of lime,	·029
Bi-carbonate of lime,	·078	Chlorid of calcium,	*trace*
Sulphate of soda,	·021	Silica,	·008

As is seen by the analysis, this water is remarkably free from solid matter, nor is it supposed by the inhabitants of the country in its neighborhood, to possess any other than the ordinary properties of water.

The geological character of the contiguous country has nothing in it that would induce one to suspect the existence of such abundant sources of warm water. The plain of *Eski-Shehr* appears to be one of those extensive lacustrine regions so common in the western portion of Asia Minor; the deposits consist of a consolidated breccia. Imbedded we find the rocks of the neighboring mountains, as well as the Meerschaum or silicate of magnesia, so extensivly worked for exportation. Thermal waters are obtained in numerous parts of the plain as well as at Eski-Shehr.

Thermal Waters of Troy.

Near the plains in which are supposed to have been situated the ancient city of Troy, are numerous sources of thermal waters, of several of which I procured specimens; only two, however, have been analyzed, the others not having arrived at my laboratory. These springs are those alluded to by Homer, and they have enjoyed more or less reputation from the time of the Trojans to the present date. The two that I have examined are saline and their sources near each other. Analysis shows them to be identical. The physical properties will be alluded to when the other waters from this locality have been examined.

Chemical Composition.—One litre contains of solid matter 21·301 grammes. The same quantity of water has in its composition

Carbonic acid, fixed, .	·0595	Lime, . . .	1·4000
Sulphuric acid, . .	·0680	Magnesia, . . .	0·3012
Chlorine, . . .	12·8000	Oxyd of iron, . .	*trace*
Bromine, . . .	*trace*	Silica, . . .	0·0600
Soda, . . .	9·2110		

Combined as follows:—

Carbonate of lime, .	·1225	Chlorid of magnesium,	·7031
Sulphate of soda, .	·0607	Bromid of magnesium,	*trace*
Sulphate of lime, .	·0540	Chlorid of iron, .	*trace*
Chlorid of sodium, .	17·4450	Silica, . . .	·0600
Chlorid of calcium, .	2·5078		

Thermal Waters of Mitylene.

On this island, the ancient Lesbos, there are several warm springs, and much of the geological structure of the place is volcanic. I visited two of the springs; the first is near to the village of Mitylene, and immediately on the shores of the gulf of Olives, it is called *Kelemyeh Oulinjah*, and there are two baths attached to it.

Kelemyeh Oulinjah source.—The water is clear, and flows without leaving a deposit. Its temperature is 102° Fah. (atmosphere at 77°), and when cold there is nothing marked in its taste.

Chemical Composition.—There are 1·250 grammes of solid matter in a litre of the water which contains the following ingredients in grammes.

Carbonic acid, free, .	·155	Soda, ...	·278
Carbonic acid, fixed, .	·075	Lime, ...	·152
Sulphuric acid, . .	·040	Magnesia, . . .	·070
Chlorine, . . .	·570	Silica, ...	·015

Combined as follows:—

Bi-carbonate of lime, .	·2450	Chlorid of calcium, .	·0865
Sulphate of soda, .	·0357	Chlorid of magnesium,	·1628
Sulphate of lime, .	·0330	Silica, . . .	·0150
Chlorid of sodium, .	·6510		

The other source visited on the island of Mitylene is about six miles north of the village, and is called *Touzla;* there are baths attached to it, and the waters are strongly saline.

Touzla source, (saline.)—*Physical Properties.*—The water does not flow clear, being more or less tinged with yellow produced by some organic acid in combination with lime. This deposit is seen to mark the course of the water as it flows down

the beach into the sea which is very near to it. Temperature of the water 117° Fah. (atmosphere at 76°.) Sp. gr. 1·0263.

Chemical Composition.—There are 34·520 grammes of solid matter in a litre of the water which contains the following ingredients in grammes:—

Carbonic acid, fixed,	·050	Lime,	2·534
Sulphuric acid,	1·648	Magnesia,	0·110
Chlorine,	18·440	Alumina,	0·012
Bromine, minute quantity not estimated.		Iron,	0·003
		Soda,	14·858

Combined as follows:—

Carbonate of lime,	·0912	Chlorid of calcium,	2·0040
Sulphate of soda,	1·4625	Chlorid of magnesium,	0·2023
Sulphate of lime,	1·3000	Carbonate of iron,	0·0038
Sulphate of alumina,	0·0221	Bromid of magnesium, minute quantity.	
Chlorid of sodium,	28·0260		

There are several other sources of thermal water in various parts of this island; the one reputed to have the greatest temperature is about eighteen miles from the latter, and called *Fezilkeh;* this source I could not visit, and can therefore say nothing of it from personal examination. There is yet one other source that I will allude to, the

Tiberiad Thermal Waters.

The source of these waters is on the border of the sea of Galilee and within a mile of the city of Tiberias, of the solid structure of which, repeated earthquakes have left but little. The surrounding country show marked evidence of extensive volcanic action.

There are several sources at the place I visited, but they seem to vary little from each other. They flow into Turkish baths, and from them pass into the sea, on their way leaving a slight yellow deposit which is doubtless, as in many of these waters, a crenate of lime.

Their temperature was not accurately ascertained for want of a thermometer, but I should consider it about 120° Fah.

Chemical Composition.—In one litre 23·540 grammes of solid matter. The same quantity of water furnished in grammes:

Carbonic acid, fixed,	·006	Lime,	·443
Sulphuric acid,	·197	Magnesia,	·119
Chlorine,	13·989	Silica,	·006
Soda,	8·751		

Combined as follows:—

Sulphate of soda,	·0620	Chlorid of calcium,	·7801
Sulphate of lime,	·0386	Chlorid of magnesium,	·1850
Sulphate of magnesia,	·0151	Silica,	·0060
Chlorid of sodium,	22·2330	Carbonate of lime,	·0106

The quantity of water brought away was too small to examine for the presence of bromine.

This is the last of the thermal waters of Asia Minor which have been examined; there are a few others that may yet reach me, when the composition will be made known as soon as examined.

Cause of the Thermal Waters in Western Asia Minor.

The cause of the abundance of warm springs in this quarter of the globe, in all formations from the alluvial to the oldest rocks, is doubtless owing to the extensive igneous action within no great depth beneath the surface of the country; a fact evinced by the frequency of earthquakes, but more especially by their extent; for they almost invariably extend from one end of it to the other, as well as to the neighboring islands.

Neither time nor change of government has contributed so much to the destruction of the hundreds of magnificent cities which once covered this country, as the desolating influence of the earthquake, and many are the cities that now exist, which have been prostrated over and over again, and rebuilt, each time in diminished splendor, until at last they are little better than collections of huts when contrasted with their original condition. All the country at the present day seems to be as much subject to them as formerly.

The only part of Western Asia Minor where phenomena are seen strictly analogous to those of active volcanoes, is in the *Catacecaumene* or burnt district, situated in Lydia, about one hundred miles east of Smyrna. Numbers of volcanic cones exist in the neighborhood of *Koola*, of many of which the craters are quite distinct, especially the one called *Kaplar Alan*, which has a perfect crater about half a mile in circumference, and two or three hundred feet deep. The extent of this region is some twenty miles long by eight broad. We have no record of any activity in these volcanoes, and Strabo described them in his day quite as they are now, and the Turks give to Satan the full credit of having created such a black parched-up district. My object at the present time is merely to mention this district, as a full description of it enters into a paper on the earthquakes and volcanoes of Asia Minor, that I propose publishing at some future time; it is brought forward now merely to show what this volcanic centre has to do with the thermal springs just described.

Remarks on the occurrence of Nitrogen in Thermal Waters.—The only substance connected with these waters that I shall allude to, is the nitrogen contained in the gas accompanying many of them, and in some instances constituting almost the entire gaseous product, as in the case of the springs of Yalova. This singular fact attracted my attention several years ago, while

examining into the gaseous products of various springs, and I then ascertained that the gas was found especially with warm springs; the nitrogen, when found accompanied with oxygen, existed in proportions much greater than in the atmosphere, and in numerous instances it was almost pure. The question naturally arises, whence comes this nitrogen? and as we know of no other natural source of nitrogen than the atmosphere, it occurs to the mind that there is a source of the gas in the thermal waters, which, before they pass to the heated substrata, absorb a certain amount of air; the oxygen of the air contained in the water combines with the rocks and minerals, or is taken up by some de-oxydizing agent in the waters, which, as they return to the surface naturally bring the nitrogen of the air freed of all or most of its oxygen.

This explanation, which appears so natural, does not, however, account for the fact, and I have been obliged to abandon it. Did the nitrogen in these waters occur in such small quantities, as we might suppose to have been absorbed by water, the explanation would hold good; but the fact in the case of the springs at Yalova and many other sources, is, that the gas, which is nearly pure, bubbles up in *great abundance*. Again, if the nitrogen evolved by springs be simply such as the water absorbs before penetrating the surface of the earth, how does it happen that this gas escapes from springs of ordinary temperature? For it is reasonable to suppose that the water having once taken into solution a gas, will not give it out except by heat or the presence of a large amount of saline matter, neither of which occur to explain the evolution of nitrogen gas from certain springs.

Feeling thus satisfied that the nitrogen in the gaseous products of springs is not owing to its absorption from the atmosphere, its origin has been sought for elsewhere, but without success, and I am constrained to believe that nitrogen is one of those elements stored up in the interior of the earth, in more or less abundance, either pure or combined, and frequently finds its way to the surface through those fissures by which mineral waters are conducted. Its more frequent occurrence with thermal waters is doubtless owing to the greater depth from which the latter come.

After all, however, that has been said, we must acknowledge the explanation imperfect, and as only furnishing another evidence of the difficulty of learning anything of the origin or uses of this singular substance, nitrogen in its elementary state.

On the Analysis of these waters, particularly with reference to the Silica and Alkalies.

The general method of analysis adopted, differed but little from that usually employed; and the construction of the salts out of the acids and bases has been made entirely from the dictates of my judgment in the matter.

The examination of the silica attracted considerable attention, from the fact that we are in the habit of always estimating it as uncombined silica, even when found in alkaline waters. Although my researches are sufficient to prove to my mind the inaccuracy of this, still I have not thought proper in this paper to deviate from the rule generally adopted, leaving it to more extended research to decide the point.

In the analysis of the waters of Broosa, nearly all of which are alkaline, the following fact has been observed; that on concentrating a considerable quantity of the water to a small bulk, all the carbonate of lime is precipitated and a portion of the silica (whether in combination with lime or not is not yet decided); but a large portion of the same still remains in solution, as well as some lime, although the water is alkaline with an excess of carbonate of soda. The silica is in such quantity that it could remain only in solution in combination with an alkali, in fact there is a silicate of soda and lime present.

The question here arises whether the silica was in a state of combination before the water was concentrated, or is it a result that has taken place during the evaporation; this question can only be decided by more extended investigation.

The observation of the above fact has led me to adopt the following method of estimating the silica in mineral waters. Take a certain quantity of the water, evaporate almost to dryness, add hydrochloric acid, a little more than is required to saturate the carbonates present; continue to evaporate to complete dryness, and then add water acidulated with a little hydrochloric acid, filter and wash the silica that remans on the filter; in this way we are sure to have the silica perfectly free from any silicate.

The method adopted for estimating the alkalies will be mentioned in a few words, as more details of it will be given in a paper devoted especially to that subject, the method has particular reference to the separation of the alkalies from magnesia.

Take the solution filtered from the silica, evaporate to dryness to drive off the excess of acid, add a little water to redissolve, then add pure lime water and filter, when the chlorids of the alkaline metals and calcium with excess of lime will pass through, the magnesia, alumina, oxyd of iron, &c., remaining on the filter. Separate the lime with carbonate of ammonia, or still better with oxalate of ammonia, evaporate to dryness, and heat to drive off the ammoniacal salts, when nothing but the chlorids of alkaline metals will be left which can be separated in the ordinary way.

This completes the description of all the thermal waters of Asia Minor which have as yet come under my notice, with the observations that the investigation have given rise to.